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LUMINARY MEMO #171

TO: Distribution
FROM: D. Eyles
DATE: September 16, 1970
SUBJECT: Introduction to ZERLINA 50

Revision 50 of ZERLINA is being sent to the simulators. It improves on its predecessor (rev. 31) by having several small-scale crew-oriented changes, and one big one— a new P66. This memo briefly describes these changes with emphasis on their operational aspects.

P63 Displays and LR Turn-on Logic

DELTAH, which used to occupy R3 of N68, is swapped for VI in R1 of N63, as shown here:

N63	DELTAH	N63	RANGE
	HDOT		TGO
	H		VI

Thus DELTAH becomes part of the normal P63 displays as Dave Scott suggested in his famous memo on "Luminary Improvements". This in turn renders superfluous the present complicated V57 logic. V57 no longer needs to have its own displays, since the commodity they offered, DELTAH, is available already. Accordingly, the LR turn-on procedure has been simplified in ZERLINA. From ignition in P63 V06N63 is flashed. When DELTAH is found reasonable, V57E is keyed in. This immediately enables LR updates and stops the flashing of the display. The flashing occurs whenever in P63 the LR is not enabled, so V58E would start it flashing again. Note that in effect V57E is the response to flashing V06N63. All other responses to this display are ignored (including V34E). Allowing PROCEED to enable updates is a possible further simplification, rejected because this would make it too easy to enable LR updates accidentally. Finally, there is scant chance of ever wanting to turn on the LR in P64 or P66, but to do so V16N63 would be used to check DELTAH before enabling with V57E.

Elimination of P63 Alignment Option

The option to do an IMU fine-alignment in P63 before PDI is removed. Gone is the V50N25 R1 00014 display - a nuisance of long-standing. Scott is the latest to suggest this delightful liquidation.

Minimum Auto-throttle in AGS

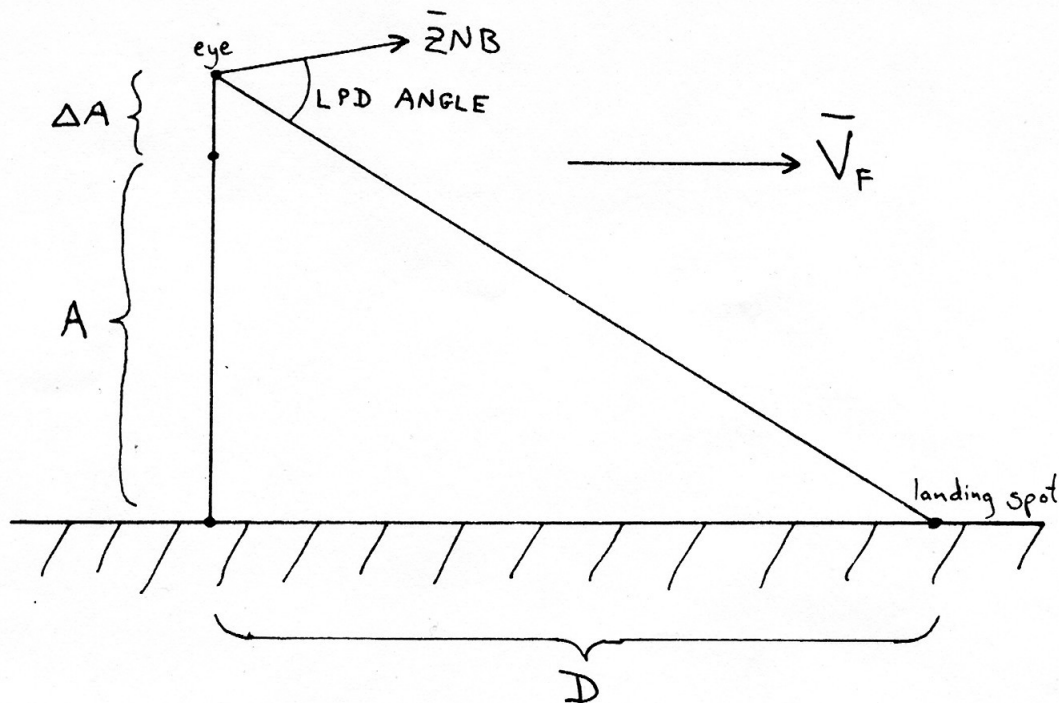
Whenever it sees that control has been given to the AGS, the landing throttle-control routine, which is processed at least every 2 seconds throughout, zeros the auto-throttle. This is to make it unnecessary to switch the throttle to manual when starting AGS to prevent PGNCS interference with the manual throttle. Note that this presumes a certain residual confidence in the PGNCS, since a total PGNCS failure might mean that the throttle routine is not being executed. It should also be noted that this change adds a new consequence to a failure of the PGNCS-AGS discrete (bit 10 of channel 3) during landing: thrust would drop to minimum.

Fly-to Cross-pointers

Next, to finish off the small stuff, the signs of the forward and lateral velocity cross-pointers are changed. This makes the cross-pointers a "fly-to" instrument in pitch and roll. This applies to both descent and ascent. The signs of the down-linked forward and lateral velocities are also changed, of necessity, but the forward velocity in N60 is not affected.

New P66

LPD. First among the P66 changes is the addition of a type of LPD capability - John Young's idea. Throughout P66, the LGC computes and displays the angle, along the LPD reticle, at which the commander can see the spot where he would land if, at that moment, he switched mode from attitude-hold to auto. In effect, he marks on the desired landing spot by switching to auto. The displayed angle is computed on the basis of altitude, forward velocity, and attitude, as shown on page 3:



The top of the triangle is at the commander's eye. Note that altitude is shown in two segments. Since LGC altitude applies to the LR antenna, ΔA is the distance between the antenna and the eye, approximated by the body X-axis difference, roughly 5 meters. D is the horizontal distance the spacecraft will travel while braking to zero horizontal velocity. \bar{ZNB} of course is the LM Z-axis.

One assumption, not too critical, is that the spacecraft is approximately erect — that is, that horizontal velocity is constant. A more important assumption is that the velocity vector is in the body X-Z-plane. This is true when lateral velocity is zero on the crosspointers. Otherwise, of course, the landing spot would not lie on the LPD reticle, but off to the side.

LPD angle is computed once per second. It is displayed in the right-hand half of R1 of N60, exactly as in N64 during P64. This angle is true when it lies between 0 and 75 degrees. Outside of these limits it is displayed as 99. In the left-hand half is displayed forward velocity to the nearest F/S with its' magnitude truncated at 99 F/S.

Quarter second decision logic. The reason the addition of LPD capability is a major change in P66 is that it necessitates deciding whether to execute the horizontal control equation, P66HZ, at more frequent intervals than is possible with the old logic — every 2 seconds.

Otherwise, there would inevitably be errors of up to $2 V_F$, depending on when, during the 2 second interval, the mark occurred. Consequently, in ZERLINA, the P66 decision logic is performed every 1/4 second in a job set up by the Landing Analog Displays interrupt (where the abort monitor is also executed). This has another advantage in that the high-quality velocity vector computed by the new LAD routine is available for use by P66HZ.

Normally, P66HZ is processed every 8 passes (every 2 seconds) and P66DISPS, which computes the LPD angle, every 4 passes, staggered from P66HZ. When mode is observed to go from attitude-hold to auto, this sequence is reinitiated, causing P66HZ to be executed immediately.

Velocity redesignation. When mode is in auto during P66, discrete deflections of the rotational hand controller modify the commanded horizontal velocity. Each click is tentatively scaled at 1 F/S. Velocity increments are in the same body coordinate system as the cross-pointer displays. This feature was proposed by Allan Klumpp as a part of the original P66 Auto, but was not implemented. It can be used to establish zero velocity relative to the surface, overcoming velocity state vector error, but it is probably more useful in performing small scale translations across the surface. In particular, after the P66 LPD capability is exercised and the LM comes to a stop above what it thinks is the desired touchdown spot, velocity redesignation can be used to overcome whatever error remains. A horizontal rate can be established in the direction of the desired spot and, at an appropriate moment, this velocity can be taken out, either by inputting clicks to cancel out the earlier ones, or by flicking mode briefly to attitude-hold, which zeroes the commanded velocity. P66 LPD could be used again here if the velocity established is great enough for the LPD angle to be in the visible region.

X-axis override is not inhibited during P66 auto, so when yawing the vehicle, it is necessary to avoid deflecting the sticks in pitch or roll as this would cause commanded velocity to be modified.

R.O.D. To reduce the computational load during P66, the ROD equation had to be rewritten. It's execution time is reduced by a factor of ten or more, P66 ROD in ZERLINA has been made faster, not just in execution time, but in performance, by taking advantage of the quarter second decision logic. A ROD click is received faster (usually within 1/4 second), and the velocity change requested is delivered

almost twice as quickly as by the competition. Some analysis of the Klumpp-Kalan type has already been performed on this version of the ROD equation and indicates that stability is not sacrificed.

Relation to Variable Servicer. Finally, I should say that the first four items discussed are independent of Variable Servicer and can be implemented in LUMINARY. However, the P66 changes cannot.